Report 1095-02-79-CR

Foreign Military Sales (FMS) Manpower Projection Methodology

Study Documentation Report
Alternative Methods for Forecasting Security Assistance Manpower

September 1979

OPERATIONS ANALYSIS GROUP
GENERAL RESEARCH CORPORATION
A SUBSIDIARY OF FLOW GENERAL INC.
7655 Old Springhouse Road, McLean, Virginia 22102

Submitted To:

Office of The Assistant Secretary of Defense
(MRA & L) (PM)
Room 3D-970, The Pentagon
Washington, D. C., 20301

Contract MDA903-79-C-0211

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General Research Corporation has developed guidance and procedures for accounting for security assistance manpower. This project has the dual purposes of: developing a means for forecasting future year manpower requirements for foreign military sales; and, for improving the current Security Assistance Manpower Accounting System (SAMAS) and the accuracy and validity of Service reports into the system. This report is concerned primarily with alternative methods for estimating Security Assistance manpower requirements.

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SECTION 1

INTRODUCTION

1.1 GENERAL

This is the second formal report of the General Research Corporation (GRC) on the "Foreign Military Sales (FMS) Manpower Projection Methodology" project. This project was undertaken for the Assistant Secretary of Defense (Manpower, Reserve Affairs and Logistics) beginning in February 1979.

1.2 OBJECTIVE

The objective of this project is to develop a standard methodology for forecasting the manpower requirements for foreign military sales. To accomplish this objective, the project encompasses three tasks:

1. Improvement of the current Security Assistance Manpower Accounting System (SAMAS), including the formulation and recommendation of necessary revisions to the SAMAS DoDI (1 Feb-31 May 1979).

2. Development of alternative strategies and methods for forecasting future-year FMS manpower requirements (1 Feb-30 Sep 1979).

3. Development of a detailed system for forecasting future-year FMS manpower requirements, including the testing of alternatives, the selection and development of a preferred methodology, and the preparation of implementing instructions for the Services (1 Oct 1979-31 Aug 1980).

Although this project was intended to be confined to FMS, the same forecasting methodology can be applied to the Military Assistance Program (MAP). Accordingly, the alternative methodologies proposed in this report encompass both FMS and MAP manpower requirements with the understanding that MAP manpower forecasts can be dropped if desired.

1.3 ORGANIZATION OF THIS REPORT

This report is concerned primarily with Task 2, our research into and development of alternative methods for forecasting security assistance manpower requirements. In Section 2, we describe our task plan and our methods of research and review. In Section 3, we describe our findings and related conclusions. In Section 4, we present our recommendations for the development and test of the alternative strategies for forecasting, the selection of a preferred method, and, finally, the implementation of the forecasting system. In Section 5, we present findings and recommendations for the improvement of SAMAS based on our most recent review of SAMAS submissions.

SECTION 2

RESEARCH METHODOLOGY

2.1 GENERAL

Our contractual plan for Task 2, Development of Alternative Forecast Methods, included the following:

- Conduct functional research
- Develop alternative methods

2.2 BACKGROUND

In response to Congressional and GAO criticisms and to correct manpower accounting deficiencies, the General Research Corporation (GRC) has developed and the Department of Defense (DoD) has implemented a "Security Assistance Manpower Accounting System (SAMAS)." It provides a standard means for the military departments and Defense agencies to report the number of personnel engaged in security assistance activities including the Foreign Military Sales (FMS) program.

In a recent review of SAMAS,[1] the GAO cited a need for prescribing more systematic and uniform methods for the military Services to program FMS manpower requirements. An effective system of forecasting manpower requirements is essential for DoD to obtain the necessary manpower ceilings to discharge security assistance obligations. This project provides for the development and ultimate implementation of such a manpower forecasting method. This report is an analysis of various alternative methodologies for FMS manpower forecasts with our recommendations for the test and validation of selected alternatives.

2.3 FUNCTIONAL RESEARCH

Our functional research into and review of manpower forecasting techniques has taken two forms: face-to-face liaison and discussion with

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[1] GAO Report FGMSD 78-47, Inadequate Methods Still Used to Account for and Recover Personnel Costs of the Foreign Military Sales Program, July 25, 1978.

Service proponents; and detailed review and evaluation of the actual FMS data reported to DSAA and available in the Services. These two efforts have been accomplished concurrently.

Close liaison has been established and maintained with Service representatives throughout the project. This relationship has been exploited effectively to provide:

- Access to Service files, records, and reports
- Access to key staff personnel of the military Services in both the departmental headquarters and certain major commands

Follow-on contacts have been made to clarify, amplify, or confirm information already obtained or conclusions already drawn. The Services have been both open and cooperative.

We have conducted an intensive review of various DSAA reporting and management information systems. Our purpose has been to discover methods for determining such data as the average time from receipt of a country request for the sale of items or services by a Service or agency to the issuance of a Service offer to the country, and the average time from the date of acceptance of an offer to the date of delivery implementation and, ultimately, to deliver completion or case closure. Such data could be useful as a basis for the development of specific components of future manpower requirements.

A number of documents of potential use in the forecasting phase were obtained during Task 1 field visits. These also have been reviewed in detail in order to discover both existing and potential methods for relating manpower to definable workloads.

Specific efforts on Task 2 have included the following:

- Consulting with OSD, DSAA, and Service officials
- Investigating the availability of statistical data on FMS cases pending, in process, and completed

- Defining and documenting potential problems and issues
- Collection of historical case data from DSAA and the Services
- Developing a classification of cases by type or function, e.g., training, weapons, non-weapons, support
- Investigating feasible methods for relating manpower utilization to functional workloads
- Investigating feasible methods for estimating volume of future support requirements
- Investigating feasible methods for relating manpower requirements to potential supply support arrangements
- Investigating feasible methods for estimating the number and value of initiated cases which will reach formal agreement and the time and manpower requirements to complete various sales actions
- Investigating methods for estimating manpower requirements for current, pending, and future cases to establish:
  - An estimate of new manpower requirements
  - A schedule of manpower to be made available as cases phase down
  - A time-phased estimate of continuing manpower requirements
- Investigating methods to estimate subjectively the manpower impact of pending, current, closing, and future cases
- Investigating methods for estimating the relationships between manpower utilization and the dollar value of current and future sales

To further our efforts, we have:

- Obtained direct computer access to FMS data contained in the DSAA FMS 1100 reporting system (the automated data base on FMS case history and records).
- Obtained direct computer access to MAP data contained in the DSAA Master Program file (the automated data base of MAP requirements, orders, and history).
- Obtained access to the Army (USASAC) FMS MIS files (the Army's central repository of automated FMS case records).

Initially, we have expected to find that our access to the DSAA and Service data bases would permit us to perform extensive statistical analyses. We found, however, that the data bases did not provide data in the quality or quantity needed to develop readily precise estimating relationships.

- There are no manpower data in case or item summary files
- Key variables are missing--there is no product or service identification in letter of request data
- Much of the data is not usable form--many iterations of data runs had to be made to get a single usable output

2.4 DEVELOPING ALTERNATIVES

In conjunction with our detailed review of the data and documentataion now available and of the forecasting methods now in use, we have examined a wide range of generally accepted and widely used forecasting techniques. In the process, it has been necessary to restate our requirement in positive and specific terms:

Develop a systematic method for projecting future year security assistance manpower requirements for the Foreign Military Sales (FMS) program for each military service in terms of

- *Full-time personnel (military and civilian) end strengths by major command and program element*

- *Full- and part-time personnel (military and civilian) man-years by major command and program element*

These forecasts must cover a period of one or more years beyond the budget year; be made (or updated) three times annually (in October, January, and May); employ common and acceptable method(s) for all Services and Defense agencies; and, satisfy the demands of the Congress, GAO, DoD, and the Services.

In our review of the forecasting requirement, we were told:

- At the military department and Defense agency level - "Just tell me what countries will be in the system and what kind of stuff they will be buying and I'll come up with my manpower requirements."
- At the field activity/operating level - "I have standards for everything I do. I don't really care what countries are in the system or what they are buying. I just predict my workload, apply the standards, and come up with my manpower requirement."

Philosophically and organizationally, the solution to the forecasting requirement probably lies somewhere between these two extremes. We have developed three conceptual methods for solving the manpower forecasting problem. All methods are dependent to some degree on a program forecast which would need to be developed and published by DoD.

2.4.1 Program Guidance

The DSAA should develop a set of program parameters for the future year(s) in such terms as "what countries will be in the system and what kind of stuff they will be buying." To this end, we have examined methods for assembling, compiling, comparing, and correlating known and/or pertinent characteristics of the security assistance programs over some historical period in order to articulate specific guidance for a future year security assistance program (Section 3.4).

2.4.2 A Macro Method

From the hypothesized "program guidance" we have examined methods for developing service-level forecasts of FMS manpower requirements using gross estimating relationships (Section 3.5).

2.4.3 An Intermediate Method

Assuming a military department can distribute the DSAA guidance by major command, we have addressed the manpower forecast requirements in terms of functions and services to be performed and the providers of those services (Section 3.6).

2.4.4 A Micro Method

Using the program guidance as bounds, we have looked at the manpower forecast requirement at the case level where the work is done and the manpower expended. This involves replicating the process, case by case; postulating each step in the process as a quantifiable workload; applying engineered/measured work standards or other manpower estimating relationships and forecasting and controlling the specific manpower requirements on a case by case basis (Section 3.7).

SECTION 3

FINDINGS AND CONCLUSIONS

3.1 GENERAL

We have considered a wide variety of generally accepted forecasting procedures that appear to offer reasonable prospect for utility and success. These possibilities range from the simple to the complex (Section 3.2). We then considered the selection of variables available in the data base: to provide the basis for a forecast (independent); and to be the subject of the forecast (dependent) (Section 3.3).

Having conceptualized the general structure of a program forecast to be issued in the form of DSAA program guidance and three methods or models for the development of manpower forecasts in Section 2, preceding, we initiated a multistep process for the definition of each forecasting technique. In Sections 3.4-3.7, we discuss the forecast methodologies in terms of a rationale, a technical approach, our preliminary testing of the data, and the results of our experimentation. Finally, we compare the forecasting methodologies with respect to adequacy, accuracy, and complexity (Section 3.8).

3.2 CONSIDERATION OF METHODOLOGIES

In the course of our review, we looked at the limited number of forecasting methods now being used, at the wide variety of forecasting methods available to meet our requirements and, at the kinds of data needed from the forecast and available in the data base. From this review, we discarded a number of methods as unsuitable and identified others with strong potential. The range of methods considered and our evaluation of each is set forth below. At Appendix A, we have provided a brief summary of some of the analytical processes that will be used.

3.2.1 Qualitative (Judgmental) Forecasts are used primarily when data are scarce, no relevant history exists or good information is nonexistent.

Such a forecasting method would rely heavily on judgment and/or interpretation.

Within the sphere of qualitative methodology, only one generally accepted method is relevant to our requirement: the Delphi method (a consensus of the unbiased opinions of experts). It appears that a limited form of the Delphi method might be the appropriate means of gaining high-level approbation of a technological forecast. This technique is implicit in the act of obtaining the State Department coordination for the DSAA-generated program forecast (Section 3.4). Other qualitative methods such as Market Research, Panel Consensus, Visionary Forecast and Historical Analogy have been examined and rejected.

3.2.2 Time-Series Analyses and Projections are used when several years' data are available and when relationship and trends are both clear and relatively stable. Time-series analysis is useful in identifying and explaining:

- Regular or systematic variations in data
- Cyclical or seasonal patterns in data
- Trends in data
- Growth rates of a trend
- Inherent randomness of data

The general nature of the historical data available and the specific nature of the forecasts to be provided seem to militate toward the use of time-series analysis as a component part of any overall method of forecasting we might propose. We looked further into the kinds of projection techniques that might be used in conjunction with the time-series analysis.

Within the sphere of time-series projection methods, exponential smoothing and learning curves offer reasonable prospects for utility. Exponential smoothing is accurate for the intermediate term (up to two years). Learning curves have value in projecting various stages of a

life cycle. Trend lines and moving averages have, for the moment, been set aside because of their limitations: good only in the short term, relatively inaccurate, unable to identify turning points.

3.2.3 Causal Models are a more sophisticated method of forecasting and are used when historical data are readily available and when the relationship between the factor to be forecast (dependent variable) and other factors (independent and/or dependent variables) can be spelled out. The objective is to develop a comprehensive model of the system to explain all the system parameters and their interactions.

The Foreign Military Sales "system" involves so many components with so many interactions that causal models offer a reasonable opportunity for success. Within the sphere of causal model methodologies, two techniques appear to be both relevant and useful.

Regression analysis (now being used successfully by the Air Force Logistics Command in two FMS applications) can handle large amounts of historical data on a large number of variables. Regression analysis serves a variety of applications with good to very good accuracy in the intermediate range and good capability to identify turning points in the short range.

Life cycle analysis offers some prospect of success. It will forecast the life cycle characteristics (growth rates) of a new requirement on the basis of the historical life cycle pattern of a family of similar requirements.

Other causal models, such as econometric, input-output, diffusion indices and leading indicators, have been examined and set aside.

3.2.4 Cross-Sectional Analysis is the evaluation of data that has been collected for a specific time period but for different individuals, organizations, or different geographical regions. Cross-sectional analysis

may be useful for extending to a new country, data which applied to other countries or to a new weapon, data which applied to other weapon systems.

3.3 CONSIDERATION OF VARIABLES

The forecasting requirement and our ultimate solution involves many possible variables. The number and variety of these variables need to be narrowed to manageable proportions and then structured for consideration. In a statistical sense, some variables will be independent and others will be dependent. It is possible that a particular phenomenon may be treated at an early stage of the process as an observed or historical variable (either dependent or independent). In a middle stage of the process, it may be a forecast dependent variable. In a later stage of the process, it may be used as an independent variable. For example, the number of case requests over a particular time period may be an observed variable in one phase, a forecast variable in the next phase, and an independent variable on which we forecast manpower in the final phase of the forecast methodology.

The identification of specific variables and the form they will take in the forecast models may be the product of a lengthy period of trial and error. We have identified the general nature of the variables which will be explored to assess both availability and utility. We have been able to examine many of these variables within the DSAA FMS data base.

Our initial consideration of variables includes:

3.3.1 Time. It appears almost foregone that all conceptual methods will involve some form of time-series. Thus, time is a very significant *independent* variable. If our forecast is the manpower requirement for a particular fiscal year, then our time variable will probably be fiscal years. In some cases, the time variable might be expressed in fiscal quarters and, in others, it might be the life cycle of a case. The final choice will

be based on the results of the data search and the specifications of the forecasting method.

3.3.2 Dollars. Dollars are a significant *independent* variable also. In which form it will be used remains to be settled. We have examined the dollar's many aspects: by country, by case, by fiscal year, by function, by Service, and by other relation/correlation.

3.3.3 Country/Client. This *independent* variable is the entry point for a host of variables, some of which are significant: number of cases, life cycle of cases, types of cases, value of cases, status of cases. Our tests for significance and utility will be methodical and orderly.

3.3.4 Service/Command/Activity. Ultimately, our forecast will be posted as the manpower requirement of a reporting service or agency. Whether we forecast at national or Service level and then disaggregate to command and activity or whether we forecast at activity level and then aggregate to command and Service level, the particular service or command or activity is an important *independent* variable to be incorporated, evaluated, and correlated in our model(s).

3.3.5 Function/Service Performed. This may be the key *independent* variable in any model. It drives the cost in dollars and manpower. It drives the service, command, and performing agency. It drives the life cycle configuration of the case. It drives the workload against which engineered or other work factors and standards are applied.

3.3.6 Manpower. This is the ultimate variable--the forecast *dependent* variable produced by the model. Because historical manpower data is seriously limited in both quality and quantity, we must search carefully for data relationship in budgets, accounting records, and other available historical records and reports. The credibility of manpower data will be assessed, factors will be developed and estimates will be made.

3.4 PROGRAM GUIDANCE

We have reviewed the historical data available in the DSAA data base. We find detail on which it should be possible to develop a substantive forecast of the security assistance program for any future year. We believe:

1. The forecast should be prepared by DSAA and coordinated with the State Department. If program guidance in the form presented here is not prepared by DSAA, the techniques discussed are applicable to each service and probably necessary to provide the basis for the other methods discussed.

2. The forecast should be published in the *Consolidated Guidance* in the form of program guidance against which the Services will prepare a security assistance program for the POM. The May SAMAS report serves as the POM submission for security assistance manpower.

3. The forecast should provide the dollar volume of anticipated sales (or grants) by Service for each country or country group by major commodity grouping.

In addition to historical data, there is considerable material available to DSAA for developing program guidance:

- Joint Strategic Planning Document (JSPD)
- Security assistance planning data submitted by MAAGs and CINCs for the Joint Security Assistance Memorandum and the Military Security Assistance Projection.
- Joint Security Assistance Memorandum (JSAM) - contains detailed objectives, program guidance, and fiscal constraints by country.
- The Military Security Assistance Projection (MSAP) - recommends the security assistance program over a five-year planning period.

- State Department guidance on the type, extent, and duration of security assistance programs by country.
- Arms Export Control Board policy guidance.
- Country assessments of security assistance requirements - three-year joint State (Defense) plan.

In his efforts to control the sale of armaments throughout the world, the President has determined that the US will set an example by reducing the transfer of weapons and weapons-related items to foreign customers. He has determined which equipments will be categorized as "weapons and weapons related" and thus included in a ceiling and he has determined which of our close allies will be exempt from this transfer ceiling. Each year, he establishes an annual ceiling on the transfer of weapons which applies to both FMS and MAP programs. Schematically, his guidance has followed the general structure below:

Weapons	Country	Non-Weapons	Training
Exempt	NATO Japan Australia New Zealand	No $ ceiling	No $ ceiling
$ ceiling	All Others		

Thus, he has created country/program groupings which may be capable of being forecast in some detail--whether on historical trends, on current agreements, on future requirements, or on explicit constraints. Whatever the method(s) developed under this project, the forecast must be subject to political review and approval.

3.4.1 Technical Approach

Security assistance program projections can be made using total program approach: a projected annual sales program by major commodity grouping (weapons, non-weapons and training) can be computed for each Service.

Both FMS sales and MAP orders are statistically dependent on (1) the specific country or country grouping and (2) the major end items in the program. It will be essential to our primary scheme of forecasting that the extraordinary countries or end item programs be separately identified and independently forecast. For example, over the period of the 70's, the FMS programs for Iran, Israel, and Saudi Arabia have been so much larger than those of any other non-exempt country, that they should be separately forecast. Initially, we will identify for separate treatment those countries whose programs have exceeded or will exceed $100 million annually. Likewise, certain aircraft, ship, and missile programs have been so large that they, too, should be separately forecast. Initially, we will select those weapon systems whose sales will exceed $100 million annually or $25 million for any country. Finally, we must also consider the effect of concurrent membership of a particular country in both the sales and grant programs.

Thus, in selecting country groupings for program projection into a selected outyear, we can divide the FMS world first into groups (exempt and non-exempt), isolate the exception countries (≥$100 million in annual sales), assign membership to each group or subgroup, and then consider both FMS and grant aid program participation. Tables 1 and 2 following show the initial country groupings selected for later testing of data and techniques.

3.4.2 Testing the Data

Initially, we developed a time series of the FMS agreements (orders) history file (FY 74 through FY 78) by country group and major commodity group. Results obtained on the "exempt" countries (Table 1) FMS Program showed:

Agreements (in $ millions)

	74	75	76	77	78
Weapons	$ 885.4	$4657.8	$1167.3	$ 916.6	$1948.9
Non-Weapons	235.2	768.4	260.1	292.5	582.4
Training	47.7	26.5	110.2	101.2	100.7
Total	$1168.3	$5452.7	$1537.6	$1310.3	$2632.0

TABLE 1

SALES AND ORDERS COUNTRY GROUPS:
EXEMPT COUNTRIES

>$100 million annually	FMS	MAP
Australia	✓	
Germany	✓	
Greece	✓	✓
United Kingdom	✓	
<$100 million annually		
Belgium	✓	
Canada	✓	
Denmark	✓	
France	✓	✓
Iceland	✓	
Italy	✓	
Japan	✓	
Luxembourg	✓	
Netherlands	✓	
New Zealand	✓	
Norway	✓	
Portugal	✓	✓
Turkey	✓	✓
NATO Organizations	✓	

TABLE 2

SALES AND ORDERS COUNTRY GROUPS:
NON-EXEMPT COUNTRIES

>\$100 million annually	FMS	MAP
China	✓	
Jordan	✓	
Korea	✓	
Pakistan	✓	✓
Singapore	✓	
Thailand	✓	✓
Iran	✓	
Israel	✓	
Saudi Arabia	✓	
<\$100 million annually		
Argentina	✓	✓
Austria	✓	✓
Bolivia	✓	✓
.	.	.
.	.	.
.	.	.
Uruguay	✓	✓
Yugoslavia	✓	✓
Zaire	✓	✓

The FY 75 data were examined carefully to isolate a specific cause (if any) of the significant one-year increase. Four countries (Belgium, Denmark, Netherlands, and Norway) within the exempt countries group had made large long-term commitments to buy F16 aircraft. Thus, we opted to consider the F16 program to be extraordinary and to be handled as an exception to the primary program forecast method.

Accordingly, we developed a new time series of the FMS agreements history file (FY 74 through FY 78). This time, the results obtained on the "exempt" countries FMS program showed:

Agreements (in $ millions)

	74	75	76	77	78
Weapons	$ 885.4	$1772.7	$1167.3	$ 916.6	$1948.9
Non-Weapons	235.2	768.4	260.1	292.5	582.4
Training	47.7	26.5	110.2	101.2	100.7
Total	$1168.3	$2567.6	$1537.6	$1310.3	$2632.0

The FY 75 and FY 78 data were examined to isolate any unique event or order that caused the increases. No specific cause could be isolated. The FY 75 increase was reflected largely in Navy orders.

Over the process of these several iterations, we noted that the four countries with annual sales in excess of $100 million comprise (on the average) about two-thirds of the exempt country FMS program. We then ran a time series of the total FMS agreements file, subdivided by country subgroup (over $100 million/under $100 million). The results were:

FMS Agreements (in $ millions)

Country Group	74	75	76	77	78
>$100 million	797.4	783.3	1084.9	909.3	1607.4
<$100 million	370.9	1784.3	452.7	401.0	1024.6
Total	1168.3	2567.6	1537.6	1310.3	2632.0

On examination, the major increase in AF sales in 1975 was primarily F100's for the Netherlands and Norway. The major increase in Navy sales in 1976 and 1978 was primarily in ship sales to Australia, missile sales to Germany, and aircraft sales to Japan, Greece, and Norway. Since the largest fluctuations over the period occurred in Air Force and Navy sales, we made a time series run on Army sales by country group. The results were:

FMA Agreements - Army (in $ millions)

Country Group	74	75	76	77	78
>100 million	173.7	195.6	184.0	200.2	319.1
<100 million	126.1	237.4	178.2	147.9	304.6
Total	299.8	433.0	362.2	348.1	623.7

On the assumption that sales may vary dramatically from year to year but that deliveries will reflect a steadier (and more predictable) level of effort, we examined the FMS deliveries history file.

We developed a time series of FMS deliveries over the same time period (FY 74 through FY 78) by country group and major commodity group. The results obtained on the "exempt" countries delivery program showed:

Deliveries (in $ millions)

Country Group	74	75	76	77	78
>$100 million	752.5	608.8	975.8	718.9	610.1
<$100 million	206.5	371.3	383.3	304.2	489.5
Total	959.0	980.1	1359.1	1023.1	1099.6

On the basis that the jump in FY 76 data reflects the "transition quarter," we shifted from fiscal years to fiscal quarters.

We have requested a new time series of the FMS delivery data. This time, we will use 21 quarterly time periods over the same five fiscal years. From this data, we will use exponential smoothing to project the FY 79 and

FY 80 programs. Since our data will be in quarters, our projections will be in quarters. Finally, we can compare actual data available for the first three quarters of FY 79 with our projections.

Next, we will integrate the MAP deliveries history file (FY 74 through FY 78) with the FMS deliveries history file and run a new time series analysis. Again, we will develop program forecasts for FY 79 and FY 80 and compare the actual data for the first three quarters of FY 79 (FMS and MAP) with our projections.

Ultimately, we will evaluate the impact of inflation on the dollar values, trends, and projections we are able to derive.

3.4.3 Results

Our limited tests of historical data--five recent years, exempt countries only, sales and deliveries--are believed adequate to confirm a reasonably high probability for the development of statistical forecasting techniques. Accurate program guidance ought to be the product of a five-step process.

1. Group (and/or isolate) the countries (further experimentation is necessary to validate such a break as $\gtrless$\$100 million).
2. Isolate the end-item programs to be handled as exceptions.
3. Perform a time-series analysis of each country, country group and end-item program.
4. Use exponential smoothing or suitable alternative techniques to project program estimates.
5. Use expert judgment to validate individual projections.

A suggested format for the DSAA Program Guidance is shown in Table 3.

3.5 A MACRO METHOD

Our concept for a macro method involves the development of estimates of security assistance manpower requirements based on such gross criteria as: total dollar volume of FMS sales and MAP grants; total dollar volume

TABLE 3

FOREIGN MILITARY SALES - (SERVICE)
($ millions)

	FY 1980	FY 1981	FY 1982	FY 1983
EXEMPT COUNTRIES				
Australia				
Weapon systems				
Aircraft, F-XX				
Tank, M-XX				
Ship, XX-				
Weapon systems support				
Non-weapon systems				
Training				
Other services				
Other Exempt Countries				
xxxxx				
NON-EXEMPT COUNTRIES				
Saudi Arabia				
Weapon Systems				
Aircraft, F-XX				
Tank, M-XX				
Ship, XX-				
Weapon systems support				
Non-weapon systems				
Training				
Other services				
Other Exempt Countries				
xxxxx				

of FMS and MAP deliveries; or total number of FMS cases or MAP orders. There is a high probability of a low correlation between such gross measures and the corresponding manpower requirement. Our limited examination of recent security assistance data support this conclusion.

3.5.1 Technical Approach

Our approach is to locate, identify, or create a manpower history file for the FMS program by Service, by year and, if possible, by major commodity group. With an accurate, reliable and acceptable base of manpower data, we would attempt to develop relations/correlations between manpower and one or more of the gross independent variables. This would probably involve the comparison of manpower with cases, dollars delivered, dollars sold, case/dollars or any other associable variable. Bivariate or multivariate regression would probably be the statistical method employed. From a projection of the independent variable of choice, a forecast of the manpower requirement would be developed.

3.5.2 Testing the Data

Historical data on security assistance manpower are both scarce and suspect. Probably the best manpower data available now are contained in recent SAMAS reports. Thus, the history file of good security assistance manpower data is extremely limited (only one fiscal year). Other manpower data can be assembled from such sources as FMS and MAP budgets and from service files but at great cost in time and effort.

We looked at dollar data by case, by country, by commodity group, by year, and, in a few cases, by work performed. Our findings were not encouraging.

Aircraft sales programs run into hundreds of millions of dollars with relatively <u>few</u> man-years of effort required even over a long-term delivery cycle. Conversely, ship overhaul programs also run into millions of dollars with <u>many</u> man-years of effort required--sometimes over a relatively short delivery period. Further, the dollar volume of a sale does not reflect whether work will be done in-house or on contract.

There is also a wide range of either dollar value or manpower requirement per FMS case or MAP order. The FY 1977 data shows one FMS case valued at $87 and another at $92,000.000. To develop a "normal" requirement for manpower per case based on such extreme case values is not likely to be useful.

3.5.3 Results

Without additional substantiation, neither OMB nor the Congress would accept such criteria as a basis for the adjustment of annual manpower ceilings. An intuitive estimate of the projected change in manpower requirement would probably be more accurate and more acceptable.

Accordingly, we suggest that further efforts on the development of a macro method to be based on such gross factors as discussed above be suspended.

3.6 AN INTERMEDIATE METHOD

Our concept for an intermediate method is based on the development of military departmental estimates of manpower requirements by command, function, and program element. Such estimates should be predicated upon program guidance provided by DSAA.

The DSAA program guidance should be provided in terms of dollars. It must be converted by the Services into workloads, e.g., tonnage, number of requisitions processed, number of procurements, man-months of training, or number of items overhauled.

It would be necessary for each military department to develop manpower standards and estimating relationships for:

- Weapon systems procurement
- Weapon systems delivery
- Weapon overhaul
- Weapon modification
- Logistics support of weapon systems

- Other logistics (supply) activities
- Accessorial activities
- Training in U.S. facilities
- Training in host facilities
- Other specified services

For each workload, the requirement for both direct and indirect (e.g., overhead) manpower must be estimated. In addition, the manpower requirement for level of effort activities, such as TAFTS, need to be estimated. Manpower requirements should be estimated by program element, by command and, as appropriate, by installation or activity. Distribution and/or allocation algorithms are required.

3.6.1 Technical Approach

Assume that the DSAA program guidance said that, for FY 198X, the exempt countries program would be about $1.2 billion; would comprise all 16 designated countries and NATO organizations; and would experience no noticeable perturbations due to the phase-in, phase-out, or significant alteration of a country program or a new weapon system.

Further, assume that $1.0 billion is in the sales program (including excess defense articles [EDA] as appropriate) and that $.2 billion is in the Grant program (including MAP, IMET, and EDA, as appropriate). A particular Service's portion of the total will be about $400 million split among the functional groups as follows: Weapons - 40%; Non-Weapons - 40%; Training - 10%; and Other Services - 10%. Finally, within the $40 million training program, $20 million will be in IMET (grants) and $20 million will be in FMS (sales).

Given this type of guidance, our research shows that the services and Defense agencies have adequate historical data on which we can develop conversion rates and factors to translate a $40 million foreign military training program into an anticipated workload, e.g., X student months of training.

The services also know that within the foreign military training program, so much will be conducted at schools and centers and so much will be conducted elsewhere (a CONUS command, a unified command, or whatever). Distribution/allocation algorithms can be developed.

Finally, the services can develop a work factor and/or relationship for each training provider (school, center, other) to estimate the manpower required, e.g., Y man-months per student month--both direct (staff and faculty) and indirect (base support).

Thus, the services, using a series of rates, factors, and relationships, can develop a manpower forecast for the training program split between grants and sales, allocated by command and, hopefully, associated with a program element.

In like manner, the services can develop factors and relationships on which a step by step forecast of manpower requirement can be made for each functional area by command and by program element.

3.6.2 Testing the Data

Having postulated a series of analytical steps that appear to be essential to the development of manpower estimates at the major command or field activity level, we have examined the methods employed, data used, and results obtained by three major Service FMS activities:

US Air Force International Logistics Center (ILC) uses rather typical statistical methods to project the Air Force Logistics Command FMS program and from the projected program value, projects both the administrative and accessorial surcharges. These estimates provide a planning constraint for the estimates of administrative and accessorial manpower required. The method involves the application of Air Force-developed support cost weighting factors for each aircraft in inventory and an ILC-developed level-of-support factor for each country in the program to the projected aircraft inventory of that country.

Navy Education and Training Command (CNET) maintains an up-to-date history file on which to develop unique factors for instruction, staff, overhead,

and support man-hours per student by course. Using the number of FMS students by course, CNET man-year requirements can be determined. Projections of the future year FMS training program reflect only current level of activity modified by known changes. Currently, there is no specific effort on the part of CNET to forecast the probable changes in training load. If Navy Headquarters, in response to the DSAA program guidance, provides CNET a forecast of the probable FMS and MAP training load, CNET can make accurate forecasts of manpower requirements.

US Air Force Logistics Command uses regression analysis to compute the relationship between man-years and workload (number of requisitions processed). Then, AFLC computes manpower requirements from a trend line projection based on number of requisitions over the preceding years. By extending the requisitions trend line into future years and applying the computed manpower relationship, a projected manpower requirement is developed. The total manpower requirement is derived by adding incrementally those requirements that were determined independently because they are not related to the number of requisitions, e.g., manpower for the F-15 and F-16 programs.

3.6.3 Results

Our evaluation of these three examples of forecasting methodology lead us to conclude that:

- Forecasting manpower by such methods is feasible
- These methods can be improved and extended to apply to other activities and other Services
- Similar methods can be developed for other FMS functions and services.

3.7 A MICRO METHOD

Our concept for a micro method is based on an assessment of the manpower requirement for each existing and potential case (or category of case) or, at least, to those cases which represent a significant manpower requirement, e.g., 3 man-months. The micro method is predicated on DSAA providing the same guidance as for the other methods.

<u>For existing cases</u>, a manpower (man-year) component would be computed using manpower standards, manpower estimating relationships, or other appropriate means (including judgment). This manpower requirement would be phased by calendar quarter to include the period in which final shipment is made or the service is completed. As appropriate, the manpower requirement for each case would be divided into the "direct," administrative," and "accessorial" components.

<u>For future cases</u>, potential agreements will be identified in the DSAA guidance based on known negotiations or plans. A manpower (man-year) requirement would be computed for each potential agreement in the same manner as for current cases. The manpower estimate could then be multiplied by a probability factor to reflect the degree of expectation of concluding the agreement. Where appropriate, the DSAA estimates of "low," "most probable," and "high" can be converted into probabilities and the agreements can be grouped according to:

- Minimum level of expected agreements
- Estimate of a country's continuing requirement to maintain equipment on hand or on order
- New agreements or major increases in scope with high, moderate, or low probability

Manpower requirements in current and future cases (adjusted by probability) can be totaled by period, by command, by function, and by program element. Man-years will be totaled and estimates of end-strengths

will be made. For each period, the totals will reflect manpower reductions to be made as a result of case completions or workload reductions, and manpower increases to be made as a result of new agreements or increases in workload.

3.7.1 Technical Approach

Without regard to political, economic, or other constraints which might be imposed, we can examine the FMS process in great detail. We can build a time-phased model of the process (Figure 1) on which we can replicate current and past activity in such a way as to develop our future year forecasts of activity levels by type and time. We can then assess the manpower requirement against the forecast activity.

We need to know:

- The time and effort associated with each step in the process:
  - From Letter of Request (LOR) to Letter of Offer (LOA)
  - From Letter of Offer to acceptance/agreement
  - From agreement to order for service
  - From order for service to completion of delivery
  - From completion of delivery to closure of case
- Experience rates, factors, or relationships between letters of request received and letters of offer tendered (including the rate of withdrawal or rejection of requests)
- Experience rates, factors, or relationships between letters of offer tendered and letters of acceptance received (including the rate of withdrawl or rejection of offers)
- The distribution of functions/services/commodities within the frequency of requests, offers, and agreements
- Weighted values of time and effort by function/service/commodity

Life Cycle of a Sales Case

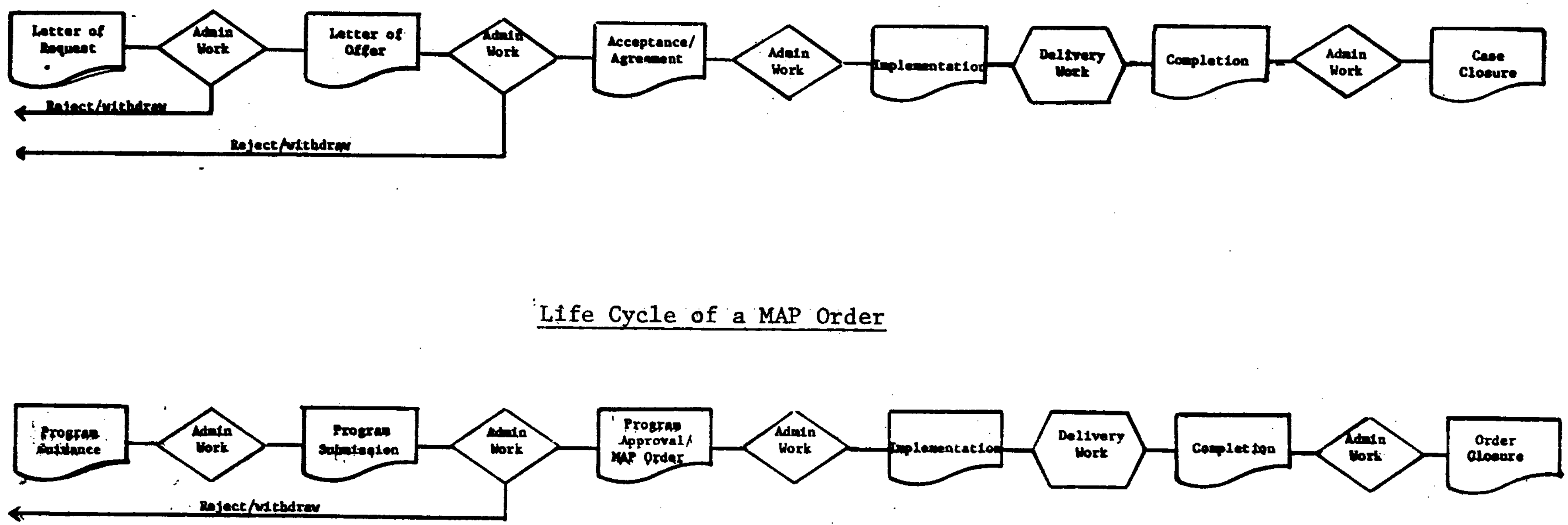

Figure 1. FMS Case/MAP Order

- Ongoing actions (according to life cycle) being taken on all cases in or to be in the system at the beginning and end of the fiscal year under consideration

Foreign Military Sales (FMS) manpower projections may be made using a micro or case by case aggregation of time and effort. Cases which do not require sufficient manpower (3 man-months) for separate treatment will be grouped, and manpower estimates made for each group on a time-phased basis. A projected annual case level by status and generic commodity or service can be computed for each performing agency. FMS and MAP manpower requirements are statistically dependent on the number of cases in process and the status of each case within the process. It is essential to our primary scheme of forecasting that we establish a precise model of the FMS case or MAP order life cycle with representative time and effort relationships between events in that cycle.

There may be a choice in forecasting method between: estimating manpower requirements for a case by time period (e.g., a year) without separate identification of the steps of the case life cycle; and, estimating manpower requirements for each step in the life cycle. We propose that both methods be tested. It would seem reasonable to estimate the man-year requirement for each phase of the life cycle in very large cases but not so reasonable for small cases.

The Services tend to have reasonably good manpower standards for application to security assistance for military training, supply activities, and depot maintenance. However, there are no effective manpower estimating relationships for administrative activities, for accessorial activities (except possibly Air Force), and for other support and service functions involved in security assistance cases. Accordingly, for the micro method to work, there would have to be some studies which would show the man-hours involved in a large scale procurement for FMS and for the other activities mentioned above.

3.7.2 Testing the Data

To develop a first order estimate of the time to perform each phase within the life cycle, we searched the FY 77 FMS history file for case closures (FY 77 was historically the lowest year for case closures in the recent history of the FMS program). Keying on the Defense-wide total of only 343 cases closed, we attempted to tabulate the dates of: request, offer, acceptance, implementation, and delivery completion. We found that the date of delivery completion is not recorded as a specific data element. With the dates available, we were able to compute the time delay between offer and agreement and between agreement and implementation.

- Mean time from offer to agreement - 56 days (with a minimum of 0 and a maximum of 270).
- Mean time from agreement to implementation - 27 days (with a minimum of 0 and a maximum of 276).

Some of the historical data necessary to construct a complete time-phased model has been lost over time (certain items are "rolled up" periodically). Yet, on a sampling basis, certain of these relationships may be reestablished. To arrive at time-phased estimates for the other two events in the life cycle (request to offer and implementation to completion) it was necessary to develop additional sampling methods.

The LOR subsystem of the DSAA data base provides an automated tri-service repository of information on letters of request and their completion or cancellation. These data are held for the current year plus any prior year LOR for which an offer has not yet been tendered. Historical LOR data is retrievable to January 1975. We designed two specific sampling procedures.

First, we queried the FMS data base to identify all letters of request received during 1978. With this sample, we requested the disposition of each and the date of that disposition (if available). Specifically, for each LOR, we obtained the date of request, the date of cancellation, or the

date an offer was tendered. A small number of cases were still open. This gave us the following data: of 5825 requests received, 1108 (19%) were canceled; 4664 (80%) offers were tendered: and 53 remained open. Mean time to process was 98 days with a standard deviation of 121 days.

Second, we queried the FMS data base to identify all cases for which a letter of offer had been tendered during FY 1978. With this sample, we requested the disposition of each offer and the date of that disposition (if available). Specifically, for each LOA, we received the date of offer, the date of cancellation, or the date of acceptance. A small number of cases were still open. This gave us the following data: of 4413 offers tendered, 695 (16%) were canceled; 3450 (78%) were accepted, and 267 remained open. Mean time to process was 56 days with a standard deviation of 85 days.

Data on case final delivery was not resident in the DSAA FMS data base. We were forced, therefore, to sample a Service data base. Specifically, we have asked the Army to identify all cases for which final delivery has been made but for which case closure had not been completed during FY 78. For each case so identified, the Army will compile the date of implementation and the date of final delivery. From these data we can develop the time delay between implementation and completion (mean, maximum, minimum). Similar data are required for Air Force and Navy and, if possible, by commodify grouping.

The time phasing and disposition data discussed above could be useful in determining the anticipated effort to be expended during the current, budget, and program years for each case in the system (current and prospective).

There is limited empirical evidence available to suggest that at each phase along the life cycle of an FMS case the times to perform each step vary by Service and by commodity, e.g., a training case takes less time and, hence, less effort for each step in its process than many of the major end-items (weapon systems) take for the same step in the process.

3.7.3 Results

The data is available, though not always easy to obtain, on which we can develop a four-step method employing a variety of statistical techniques.

1. Using time series analysis, we can project the number of letters of request to be received and, of these, the probable number to be canceled and to become offers--probably by commcdity group.

2. Using time series analysis, we can use the estimated number of offers to be issued to project the probable number of cancellations and acceptances--probably by commodity group.

3. Using life cycle analysis, we can project the phase (and associated time and effort) for each case or order in the life cycle--probably by commodity group.

4. Using simple algorithms, we can distribute the time and effort requirements to provide a manpower projection.

3.8 COMPARISON OF METHODS

In accomplishing this task, we looked at a number of alternatives for a manpower forecast methodology. We looked at each method initially in two regards: will it provide the kind of projections (forecasts) we require; and, is the data available on which to base the forecast. This evaluation led to the rejection of certain methods and a more detailed evaluation of those that showed some promise. Our further evaluation led to some conclusions on the ultimate accuracy and acceptability of the methods. Our comparative analysis of the four methodologies set forth in the preceding sections is shown in Table 4 (for simplicity we use only three adjectival ratings):

TABLE 4

COMPARISON OF FORECAST METHODS

	Forecast Accuracy	Data Availability	Design Complexity	Client Acceptability
PROGRAM FORECAST				
Time Series Analysis Exponential Smoothing Judgment	Medium	Medium	Medium	High
MANPOWER FORECASTS				
Macro Method				
Factors/Relationships Regression Analysis	Low	Low	Low	Low
Intermediate Method				
Regression Analysis Work Standards Cross-section Analysis	Medium	Medium	Medium	Medium
Micro Method				
Time Series Analysis Life Cycle Analysis Work Measurements Cross-section Analysis	High	Medium	High	High

In no case, did we find the availability of data to be a major positive factor; manpower data is very difficult to derive and most other data is available only with difficulty. Except for a relative simplicity of system design, we found the *macro* method to be lacking in all other characteristics.

SECTION 4

RECOMMENDATIONS AND FUTURE PLANS

4.1 GENERAL

During Task 2, we concentrated our primary efforts on the development of alternative strategies and methodologies for forecasting future year security assistance manpower requirements. Our primary interest has been in forecasting manpower for the Foreign Military Sales (FMS) program, but for consistency and completeness, we have addressed also the military assistance component (MAP) of the security assistance program. The ultimate forecasting strategy should be capable of handling both FMS and MAP.

During the next phase, we will develop, test, and validate some of the methods articulated in Section 3 in sufficient detail to permit a later recommendation by this team and decision by DoD to implement a method or combination of methods within the security assistance community.

4.2 RECOMMENDATIONS

In that regard, it is appropriate now to make certain recommendations which influence our future course of action:

1. We recommend that DoD instruct the DoD components to incorporate a manpower requirement in each planning and budgeting estimate (P&B) and each price and availability estimate (P&A) prepared in support of a letter of request or letter of offer. Further, we recommend that the manpower estimate be carried forward in each case or agreement record (history file).
2. We recommend no further consideration be given to a *macro* method of manpower forecast (Section 3.5).
3. We recommend that the *intermediate* method (Section 3.6) be developed, tested, and validated for early implementation.

4. We recommend that the *micro* method (Section 3.7) be developed concurrently with the *intermediate* method and that it replace the *intermediate* method when proven.

On the assumption that these recommendations are acceptable, our plan for the accomplishment of Task 3 (and particularly, for the testing and analysis of alternatives) follows.

4.3 TASK PLAN

We will coordinate this report with the Defense Security Assistance Agency (DSAA) in order to:

- Obtain agreement on form, content, preparation and publication of the program guidance
- Prepare and issue instructions to the military Services and Defense agencies which will require manpower estimates to be included in P&Bs, P&As, and similar estimates and then recorded in the FMS and MAP history files

We will coordinate this report with the military Services and Defense agencies in order to:

- Determine the availability of and plans for development of manpower estimating relationships for: weapons procurement; weapons delivery; weapons overhaul; logistics support of weapons; other logistics (supply) activities; accessorial activities; training; other services
- Assist in the development of manpower estimating relationships for activities in which they are inadequate.

We will develop, test, and validate the forecasting methods using extensive automated data retrieval, manipulation and, in some cases, simulation techniques:

- Applying manpower estimating relationships to prior year cases and prior year data to evaluate their adequacy and accuracy

- Develop methods for handling "sales" not subject to a manpower estimating relationship, e.g., TAFTS

- Develop and test case/order life cycle time intervals standards from request, to offer, to agreement, to delivery

We will determine how these standards can be applied.

We will report the results of our development, test, and validation activities and provide specific recommendations for the system development and implementation.

We will assist DSAA in developing program guidance for inclusion in Consolidated Guidance.

We will revise the SAMAS DoDI to incorporate the necessary instructions to implement the selected methodology for manpower forecasting.

SECTION 5

SAMAS IMPROVEMENT

5.1 ACTIONS

DoDI 1100.17, "Security Assistance Manpower Accounting System," was signed on 18 July 1979 and distributed. The Services are preparing formal implementing instructions to the field.

OASD(MRA&L) Memo, "DoDI 1100.17, Security Assistance Manpower Accounting System" 22 Aug 79, was sent to the DoD components providing interim changes to the DoDI.

OASD(C) Memo, "Proposed FYDP Structure Changes (OASD(MRA&L),"
for Program 10, Support of Other Nations, has been developed and sent to the Services and Defense agencies for comment.

5.2 FINDINGS AND CONCLUSIONS

Our detailed review and evaluation of the May Servicw SAMAS reports produced the following general findings:

- The Services and Defense agencies are gradually implementing SAMAS.
- Some Service commands have not implemented SAMAS.
- Some Service commands are using inadquate procedures for estimating and reporting FMS manpower.
- There are significant and unexplained differences between SAMAS data and the corresponding FMS/MAP budgets.
- Program elements (PE) continue to be misreported. There are significant differences between manpower programed by PE in the FYDP and manpower reported by PE in SAMAS.
- The significant discrepancies among the Services in reporting accessorial manpower are getting worse.

- Both guidance and training at the reporting levels are lacking.

5.3 RECOMMENDATIONS

1. Field training should be conducted for all commands charged with the preparation of SAMAS reports.
2. Service SAMAS reports should be subjected to thorough review with corrective action.
3. Service SAMAS reports should be used to verify and support DSAA budget inputs.
4. An effective and consistent method for identifying, estimating, and reporting accessorial manpower should be developed.

REGRESSION ANALYSIS

Regression analysis is the basic tool in time-series analysis. Regression analysis is a method for determining what relationship exists between two or more variables. The variable from whose values a prediction is to be made is denoted by X, and will be considered the independent variable. For time-series analysis, X, the independent variable, is time. The variable whose value is to be estimated or predicted will be designated as Y, and considered the dependent variable. The graphical representation of a set of pairs of values of X and Y is called a scatter diagram.

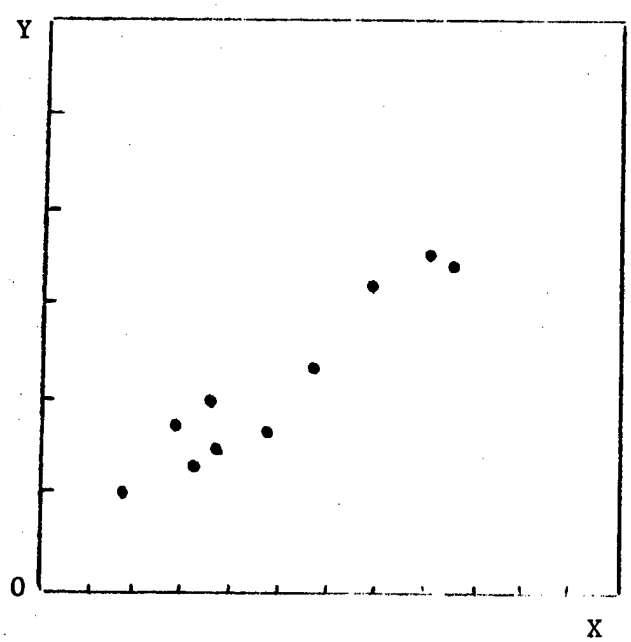

Figure 2. Scatter Diagram

The general equation for the line of regression fitted to a set of n points (X,Y) by the method of least squares is

$$Y_e = a + bX$$

where
$$b = \frac{\Sigma XY - n\overline{XY}}{\Sigma X^2 - n\bar{X}^2}$$

and
$$a = \overline{Y} - b\overline{X}$$

The line of regression is fitted to the data as shown.

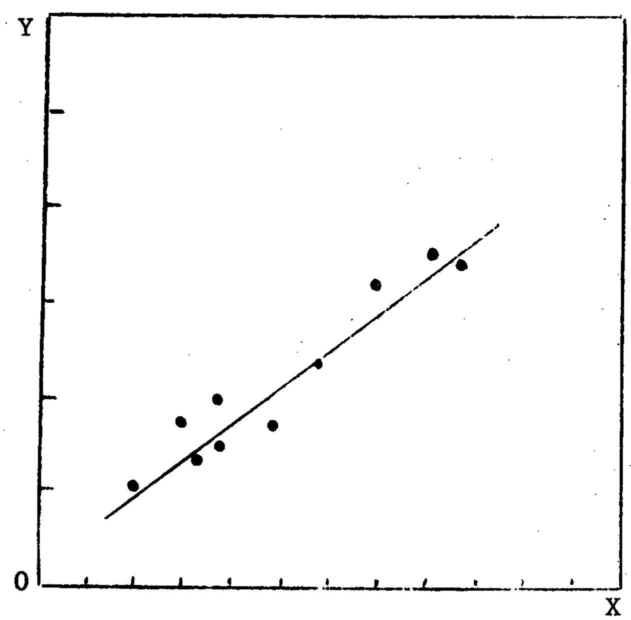

Figure 3. Regression line fitted to data on Figure 2.

The forecast value of Y can be determined algebraically by solving the equation for a specific value of X or graphically by determining the value of Y corresponding to the specific value of X.

TREND LINES

Four types of trend lines may be used to describe the relationship between two variables. Each utilizes the same basic methodology in its derivation: regression analysis using the method of least squares or a simple variation thereof.

Arithmetic straight-line trend	$Y_t = a + bx$
Second degree trend line	$Y_t = c + bx + ax^2$
Logarithmic trend line	$\text{Log } Y_t = a + bx$
Logarithmic second degree parabolas	$\text{Log } Y_t = c + bx + ax^2$

where x is the independent variable (time)

and Y_t is the dependent variable

PERCENT OF TREND

When a time-series consists of annual data only, seasonal variations are not a factor. Thus, the relevant deviations are the cyclical fluctuations and irregular movements. These may be observed by dividing the original annual data by the corresponding trend figures for the same time period and then multiplying by 100% to find the percent of trend:

$$\text{Percent of trend} = \frac{Y}{Y_t} \times 100\%$$

where

Y = original annual data

Y_t = trend values

The following are graphs of a straight-line trend and its corresponding percent of trend.

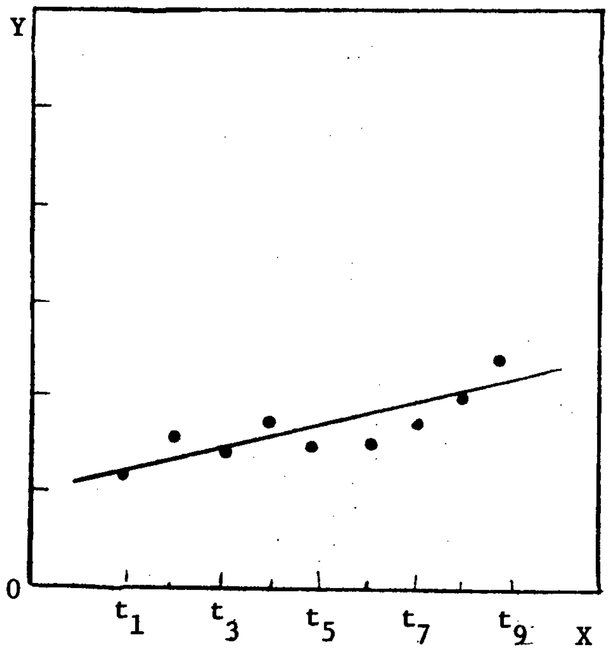

Figure 4. Time-Series with Straight Line Trend of Data on Figure 1.

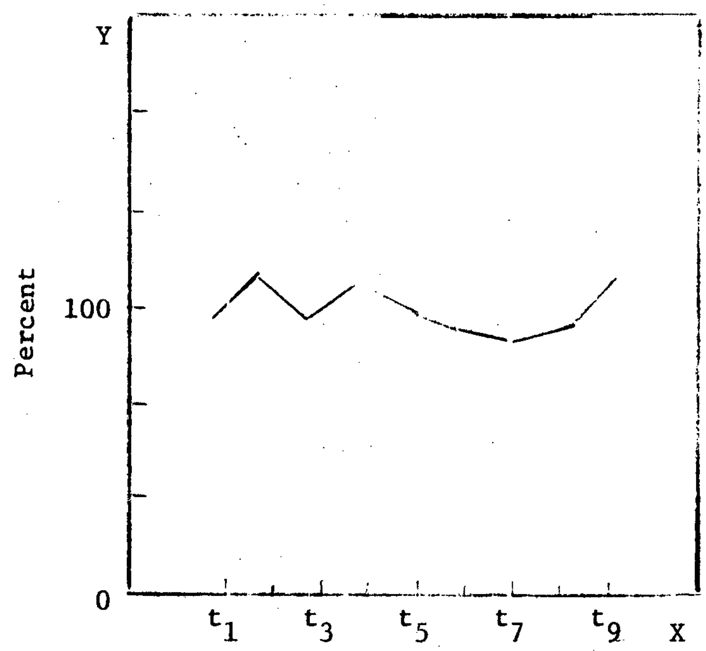

Figure 5. Time-Series as a Percent of Trend of Data on Figure 4.

" ... if the original figure is exactly equal to the trend figure, the percent of trend is 100; if the original figure exceeds the trend value, the percent of trend is above 100; if the original figure is less than the trend value, the percent of trend is below 100."[1]

Percent of trend does not take into account the effects of seasonal variations. The technique generally used to measure seasonal variations is the *ratio-to-moving average method.* Although simple in theory, this technique requires several steps and numerous calculations and is therefore not discussed here at length.

[1] Ibid, p.556.

GROWTH CURVES

The kind of curve that characterizes many American industries is the growth curve. Growth curves are also referred to as *learning curves* and *logistics curves*. Growth curves can be either arithmetical or semilogarithmic. The arithmetical growth curve has an arithmetically-ruled vertical scale. "Hence, equal vertical distances represent equal *amounts* of change."[1] The semilogarithmic curve has a logarithmically-ruled vertical scale. "Hence, equal vertical distances represent equal *percentage rates* of change."[2]

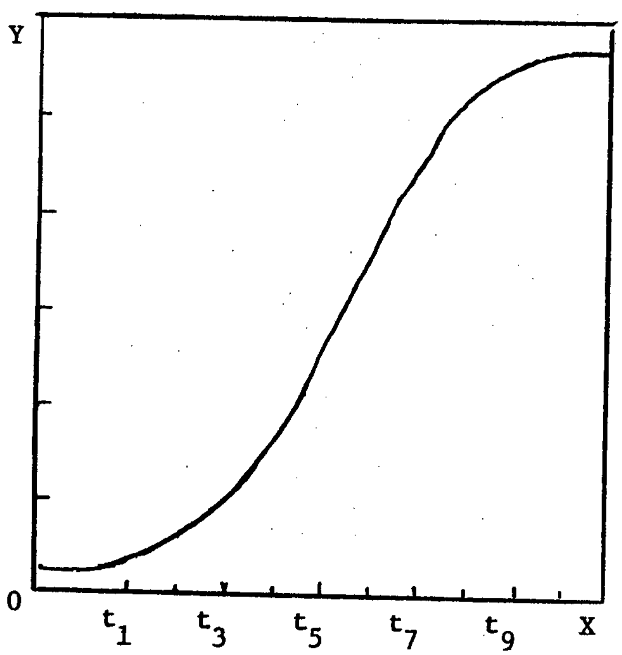

Figure 6. Growth Curve on Arithmetic Scale

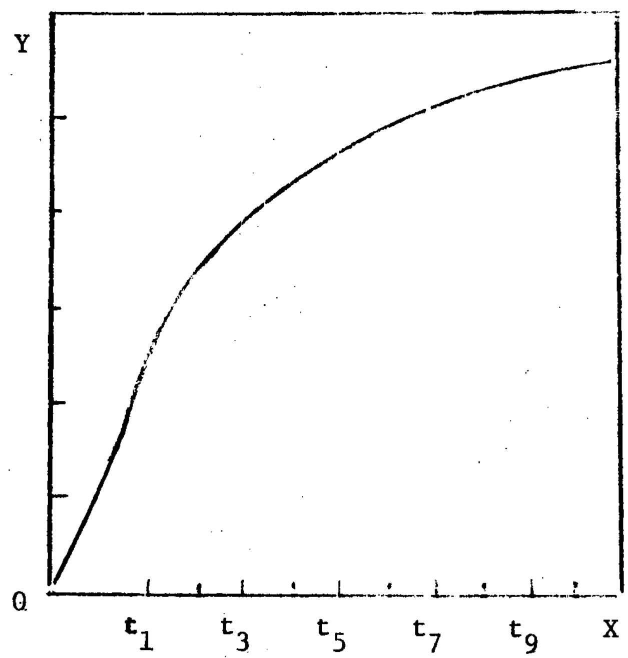

Figure 7. Growth Curve on Semilogarithmic Scale

The curve that represent the growth pattern can be expressed by the equation:

$$Y_e = \frac{K}{1 + be^{-aX}}$$

where a, b, and K are constants determined from the time-series and e is approximately 2.71828.

[1]Ibid, p. 548

[7]Ibid